State-of-the-art ultrasonic testing (UT) systems for nuclear and fossil power plant components rely on expensive mechanized scanning devices. More commonly applied manual UT methods may lead to overly conservative interventions. EPRI is creating an advanced, hand-held system that could revolutionize nondestructive evaluation (NDE) programs by delivering real-time ultrasonic images matching or exceeding the precision provided by automated techniques at a fraction of the expense.

Why are advanced ultrasonic inspection methods needed?
Periodic UT inspection is used to detect and quantify service-induced degradation, conduct condition assessments, and support run/repair/replace decisions. Most inspections employ manual UT, which is inexpensive but effective in detecting safety-significant cracking and other defects. Manual UT, however, supports only qualitative condition assessment as the scan is performed, requiring conservative results interpretation that can lead to shorter inspection intervals and premature or unnecessary repairs and replacements.

Automated UT inspection systems record the exact position of the transducer as raw ultrasonic data are collected during a scan. This allows accurate, 3-D images of the volume of components to be encoded, stored, reconstructed, and manipulated, which enables quantitative analysis and leads to better decision-making. Though extremely valuable for certain applications, mechanized robotic scanning devices are more expensive than manual UT systems by an order of magnitude. They require time-consuming setup and are subject to occasional mechanical breakdowns that may impact the desired inspection scope and outage critical path. They also cannot access many as-built configurations.

What is EPRI’s role?
EPRI is creating an innovative manual inspection system to enable high-accuracy, real-time ultrasonic imaging at much lower cost than today’s robotic devices and for a broader range of component configurations. This innovative NDE system will integrate migration-array UT with a hand-held “acoustic mouse.”

Array technology, developed for medical imaging and adapted by EPRI over the past decade for NDE applications, employs a probe consisting of multiple ultrasonic elements. Advanced
Reflector reconstruction codes called migration generate a real-time ultrasound image of specific internal features within a component by a comprehensive 3-D representation.

The acoustic mouse is an ultrasonic transducer that an operator can manually roll over a component’s surface. Scanning data are acquired and reconstructed into 3-D views of the component’s interior using phased-array image processing techniques as well as ultrasound tomography algorithms. Real-time signal variation methods extract positional information for the transducer from unique material characteristics observed throughout the component.

What are accomplishments to date and next steps?
Proof-of-concept experiments suggested that special tracking techniques of acoustic scatterers within a material may be used to uniquely identify an ultrasonic transducer’s location. This supported conceptual design of an integrated system incorporating an acoustic mouse and associated sensors and analytics. EPRI is augmenting the system to incorporate the latest advances in real-time 3-D reconstruction, phased-array, and beam-forming technology for accurate flaw detection, damage monitoring, and condition assessment. Additional internal imaging and surface mapping techniques are being evaluated, including animation capabilities like those created for movie and video game applications. Laboratory testing and hardware and software development are targeted toward field demonstration of a prototype in 2012. Within three years, EPRI expects hand-held acoustic imaging technology to be ready for qualification testing and commercial application in the power generation industry and other sectors.

What are anticipated benefits?
The migration-array acoustic mouse system is expected to reinvent encoded UT from an expensive, niche technology to a mainstream NDE solution, significantly improving inspection accuracy, component reliability, and plant safety while eliminating costly and unnecessary maintenance tasks. It will allow manual inspections to be performed with equivalent or better accuracy than today’s best automated ones at about 70% of the cost, corresponding to roughly $100,000 in savings per avoided robotic scanning setup. In addition, quantitative condition assessment will be possible for more components rather than limited to only those locations that can accommodate a fully automated system.

Better NDE data will support informed run, repair, and replace decisions and enhanced asset management. Depending on the component and circumstance, savings associated with avoiding unnecessary interventions could range from tens of thousands on up to millions of dollars. By increasing regulatory confidence in the integrity of safety-critical components at existing nuclear plants, this system also could support long-term operations up to and beyond 60 years.

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